AS 658

ASL R2711

2012

# Nation-Wide Evaluation of Colostrum Quality

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## A.S. Leaflet R2711

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### Summary and Implications

Samples of maternal colostrum **(MC)** were collected from 67 farms in 12 states between June and October, 2010 to determine IgG concentration and bacterial contamination. Samples were identified by breed, lactation, and if the sample was fresh, refrigerated or frozen prior to collection. Concentration of IgG in MC ranged from < 1 to 200 mg/ml, with a mean IgG concentration of 68.8 mg/ml. Nearly 30% of MC contained < 50 mg of IgG/ml. The IgG concentration increased with parity (42.4, 68.6, 95.9 mg/ml in 1st, 2nd, and 3rd and later lactations, respectively). No differences in IgG concentration were observed among breeds or storage method, however, IgG was highest in samples collected in the Midwest and lowest in samples collected in the Southwest (79.7 vs. 64.3 mg/ml). Total plate count **(TPC)** of samples ranged from 3.0 to 6.8 $\mathrm{Log}_{10}$ cfu/ml with a mean of 4.9 $\mathrm{Log}_{10}$ cfu/ml (SD = 0.9) and was greater in samples collected in the Southeast compared with other regions of the country. Pooled samples had greater TPC than individual samples and refrigerated samples had greater TPC than frozen and fresh samples. Nearly 43% of samples collected had TPC > 100,000 cfu/ml, 16.9% of the samples were > 1 million. Only 39.4% of the samples collected met industry recommendations for both IgG concentration and TPC. These data suggest that nearly 60% of MC on dairy farms is inadequate, and a large number of calves are at risk of failure of passive transfer and/or bacterial infections. These data also suggests regional differences in MC quality.

### Introduction

Maternal colostrum **(MC)** provides the neonate with immunoglobulins **(Ig)** essential for passive immunity. Carbohydrates, fat, and protein in MC are also essential as metabolic fuels to the newborn. Vitamins and minerals in MC are essential as co-factors for enzymes and general maintenance functions. Colostral IgG concentration is essential to ensuring adequate passive transfer. Bacterial contamination of MC is another critical quality parameter. Bacteria in MC may bind free IgG in the gut lumen or block uptake and transport of IgG molecules into the enterocytes, thus reducing apparent efficiency of IgG absorption.

Current industry recommendations include discarding MC that contains < 50 mg IgG/ml and > 100,000 cfu/ml total plate count **(TPC)**. The objectives of this study were to 1) determine the IgG concentration and bacterial composition of MC available on U.S. dairy farms 2) differences in MC across regions, storage methods, breeds and parity and 3) estimate the percentage of MC available that meets industry standards for both IgG concentration and bacterial contamination.

### Materials and Methods

Dairy farms (n = 67) in 12 states participated in the study between June and October, 2010 (Table 1). States were grouped into 4 regions: Northeast (NH, NY, PA), Southeast (FL, GA, VA), Midwest (IA, MN, WI) or Southwest (AZ, CA, TX). Samples of MC were collected based on availability of MC at the time of site visit. The MC was sampled from individual cows or from multiple

**Table 1. Colostrum samples collected across region, state, breed, lactation and storage method**

| | | | Breed | | | Lactation | | | | | Stored[1] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Region<br>State | Farms | Samples | Holstein | Jersey | N/A[2] | 1 | 2 | 3 | 4+ | N/A[2] | 1 | 2 | 3 |
| **Northeast** | | | | | | | | | | | | | |
| NH | 1 | 18 | 18 | ~ | ~ | ~ | 6 | 3 | 9 | ~ | 18 | ~ | ~ |
| NY | 5 | 59 | 41 | 3 | 15 | 4 | 11 | 4 | 2 | 38 | 17 | 29 | 13 |
| PA | 5 | 51 | 42 | 9 | ~ | ~ | 5 | 17 | 22 | 7 | ~ | 23 | 28 |
| **Southeast** | | | | | | | | | | | | | |
| FL | 4 | 35 | 33 | 2 | ~ | 1 | 22 | ~ | ~ | 12 | 17 | 9 | 9 |
| GA | 2 | 30 | 30 | ~ | ~ | ~ | 30 | ~ | ~ | ~ | 11 | 19 | ~ |
| VA | 7 | 60 | 22 | 3 | 35 | ~ | 2 | 1 | ~ | 57 | 25 | 20 | 15 |
| **Midwest** | | | | | | | | | | | | | |
| IA | 1 | 40 | 40 | ~ | ~ | ~ | | ~ | ~ | 40 | ~ | ~ | 40 |
| MN | 11 | 97 | 35 | ~ | 62 | 8 | 10 | 4 | 5 | 70 | 2 | 6 | 89 |
| WI | 6 | 27 | 27 | ~ | ~ | ~ | 5 | ~ | ~ | 22 | ~ | ~ | 27 |
| **Southwest** | | | | | | | | | | | | | |
| AZ | 2 | 61 | 40 | ~ | 21 | 2 | 7 | ~ | ~ | 52 | 7 | 9 | 45 |
| CA | 14 | 173 | 161 | 8 | 4 | 34 | 76 | ~ | ~ | 63 | 93 | 34 | 46 |
| TX | 9 | 176 | 5 | 62 | 109 | ~ | | 61 | ~ | 115 | 6 | 3 | 167 |
| **TOTAL** | **67** | **827** | **494** | **87** | **246** | **49** | **174** | **90** | **38** | **476** | **196** | **152** | **479** |

[1]Location where colostrum was stored prior to sampling. 1 = fresh/not stored, 2 = refrigerator, 3 = freezer.

[2]Breed and lactation information were not available if samples were pooled prior to collection.

cow pools according to the normal management of the farm. A 50-ml sample of MC was collected using a sterile dipper and divided into two sample vials, frozen, placed on dry ice and shipped to the respective laboratory for analysis of IgG, nutrient composition and bacterial contamination. Samples were classified based on storage prior to feeding: fresh, refrigerated, or frozen. Additional information, including breed, and lactation number were recorded for each sample. The IgG concentration was determined by radial immunodiffusion, nutrient composition and bacterial analysis was conducted at the DHI laboratory (Dubuque, IA). Results were analyzed using the PROC GLM procedure of SAS.

**Table 2. Overall sample means for IgG, nutrients and bacterial contamination.**

| | n | Mean | SD[1] | Minimum | Maximum |
|---|---|---|---|---|---|
| IgG (mg/ml) | 827 | 68.8 | 32.9 | <1.8 | 200.2 |
| Fat (%) | 531 | 5.6 | 3.2 | 1.0 | 21.7 |
| Protein (%) | 542 | 12.7 | 3.3 | 2.6 | 20.5 |
| Lactose (%) | 538 | 2.9 | 0.5 | 1.2 | 4.6 |
| Other Solids (%) | 544 | 4.3 | 0.5 | 1.1 | 8.8 |
| Total Solids (%) | 496 | 22.6 | 4.7 | 1.7 | 33.1 |
| SCC Log$_{10}$ | 548 | 5.9 | 0.8 | 3.8 | 7.3 |
| TPC Log$_{10}$ | 548 | 4.9 | 0.9 | 3.0 | 6.8 |

[1]SD = Standard deviation

## Results and Discussion

A total of 827 MC samples were analyzed for this study. Overall sample means for IgG, fat, protein, total solids, other solids, SCC, coliform and TPC are in Table 2.

Samples from the Midwest had greater IgG concentrations and samples from the Southeast and Southwest had the lowest IgG concentration (Table 3). Fat content of MC was greatest in samples from the Midwest. Protein content was greater in the Midwest and Northeast. The concentration of lactose was lowest in the Southeast. Somatic cell and coliforms were greatest in the Southwest.

**Table 3. Nutrient and bacterial means by region of the country.**

| | Region[1] | | | |
|---|---|---|---|---|
| | Northeast | Southeast | Midwest | Southwest |
| IgG (mg/ml) | $71.5^{b}$ | $66.9^{ab}$ | $79.7^{c}$ | $64.3^{a}$ |
| Fat (%) | $5.9^{ab}$ | $5.2^{a}$ | $6.4^{b}$ | $5.2^{a}$ |
| Protein (%) | $13.6^{b}$ | $12.3^{a}$ | $13.5^{b}$ | $12.1^{a}$ |
| Lactose (%) | $3.0^{c}$ | $2.7^{a}$ | $2.9^{bc}$ | $2.9^{b}$ |
| Other Solids (%) | $4.8^{b}$ | $4.3^{a}$ | $4.3^{a}$ | $4.3^{a}$ |
| Total Solids (%) | $23.8^{b}$ | $20.6^{a}$ | $24.1^{b}$ | $21.6^{a}$ |
| SCC Log$_{10}$ | $5.7^{a}$ | $5.8^{ab}$ | $5.9^{ab}$ | $6.0^{b}$ |
| TPC Log$_{10}$ | $4.9^{a}$ | $5.7^{b}$ | $4.9^{a}$ | $4.8^{a}$ |
| Coliform Log$_{10}$ | $1.3^{b}$ | $1.1^{a}$ | $1.0^{ab}$ | $1.5^{c}$ |

[1] Region: Northeast (NH, NY, PA), Southeast (FL, GA, VA), Midwest (IA, MN, WI), Southwest (AZ, CA, TX).
[2] SE = Standard error
[abc]Means in the same row with different superscripts differ ($P < 0.05$).

Coliform counts and TPC was greatest in refrigerated samples compared to fresh or frozen samples (Table 4).

**Table 4. Nutrient and bacterial means by storage method prior to sample collection**

| | Storage Method | | | |
|---|---|---|---|---|
| | Fresh | Refrigerated | Frozen | SE[1] |
| IgG (mg/ml) | 69.0 | 74.6 | 66.3 | 7.3 |
| Fat (%) | 4.9 | 5.4 | 5.6 | 0.5 |
| Protein (%) | $10.9^{a}$ | $14.1^{c}$ | $12.56^{b}$ | 0.6 |
| Lactose (%) | $3.2^{b}$ | $2.8^{a}$ | $2.9^{a}$ | 0.1 |
| Other Solids (%) | $4.6^{b}$ | $4.3^{a}$ | $4.4^{a}$ | 0.1 |
| Total Solids (%) | $21.2^{a}$ | $24.2^{b}$ | $22.3^{a}$ | 0.9 |
| SCC Log$_{10}$ | $5.8^{b}$ | $5.5^{a}$ | $5.6^{b}$ | 0.1 |
| Coliform Log$_{10}$ | $1.1^{a}$ | $1.6^{b}$ | $1.3^{a}$ | 0.1 |
| TPC Log$_{10}$ | $4.0^{a}$ | $5.0^{c}$ | $4.5^{b}$ | 0.1 |

[a-c] Means within a row with different superscripts differ ($P < 0.05$)
[1] SE = Standard error

**Table 5. Nutrient and bacterial means by breed, lactation and storage.**

| | Breed | | Lactation | | |
|---|---|---|---|---|---|
| | Holstein | Jersey | 1 | 2 | 3+ |
| IgG (mg/ml) | 74.2 | 65.8 | $42.4^{a}$ | $68.6^{b}$ | $95.9^{c}$ |
| Fat (%) | 5.3 | 5.3 | $6.6^{c}$ | $4.2^{a}$ | $5.1^{b}$ |
| Protein (%) | 12.5 | 12.6 | 12.4 | 12.1 | 13.1 |
| Lactose (%) | 3.0 | 2.9 | $3.0^{ab}$ | $2.8^{a}$ | $3.1^{b}$ |
| Other solids (%) | 4.4 | 4.4 | $4.4^{b}$ | $4.2^{a}$ | $4.6^{b}$ |
| Total solids (%) | 22.2 | 23.0 | $23.5^{b}$ | $20.8^{a}$ | $23.4^{b}$ |
| SCC Log$_{10}$ | $5.9^{b}$ | $5.3^{a}$ | $6.0^{c}$ | $5.6^{b}$ | $5.3^{a}$ |
| Coliform Log$_{10}$ | $1.5^{b}$ | $1.2^{a}$ | $1.2^{a}$ | $1.5^{b}$ | $1.3^{a}$ |
| TPC Log$_{10}$ | $4.9^{b}$ | $4.1^{a}$ | $4.5^{ab}$ | $4.7^{b}$ | $4.3^{a}$ |

[a-c] Means within a row with different superscripts differ ($P < 0.05$).
[1] SE = Standard error

No differences in nutrient composition were observed across breeds. Somatic cell count, coliform and TPC was greater is samples collected from Holsteins compared to Jerseys (Table 5). IgG concentration increased as lactation increased while SCC decreased as lactation increased.

The data presented in this paper represents MC that was available to feed calves during the months of June through October, 2010 and is not necessarily representative of the MC produced by all dairy cattle in the U.S. during all seasons. Colostrum that was discarded after milking and never entered the feeding pool was not sampled. Storage method was determined by where the MC was stored prior to collection of the sample; it does not indicate the temperature or length of storage time. It is well known that nutrient and IgG composition of MC changes throughout the first six milkings postpartum and can be influenced by breed, parity dry period length, time of milking post-partum and individual farm.

Mean IgG concentration of samples collected was similar to previous reported data. Similar to previous research, IgG concentration increased in MC as parity increased.

Current industry recommendations include discarding MC with less than 50 mg/ml IgG. In this study 29.4% of MC that had IgG concentrations less the recommended IgG level (Table 6), thus potentially putting nearly 30% of U.S. calves at risk of failure of passive transfer **(FPT)**. The overall percentage of samples containing < 50 mg/ml IgG is lower than the 57.8%

**Table 6. Percentage of samples meeting one or both industry recommendations for colostrum quality.**

| | Overall Data Set | | Region | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Northeast | | Southeast | | Midwest | | Southwest | |
| Quality | n | (%) | n | (%) | n | (%) | n | (%) | n | (%) |
| > 50 IgG and < 100,000 TPC | 294 | 39.4 | 58 | 45.3 | 17 | 14.9 | 88 | 53.7 | 177 | 43.2 |
| > 50 IgG and > 100,000 TPC | 233 | 31.2 | 32 | 25.0 | 54 | 47.4 | 51 | 31.1 | 96 | 23.4 |
| < 50 IgG and > 100,000 TPC | 104 | 14.0 | 28 | 21.9 | 14 | 12.3 | 14 | 8.5 | 83 | 20.2 |
| < 50 IgG and < 100,000 TPC | 115 | 15.4 | 10 | 7.8 | 29 | 25.4 | 11 | 6.7 | 54 | 13.2 |
| Total | 746 | 100 | 128 | 100 | 114 | 100 | 164 | 100 | 410 | 100 |

reported in a study that represented MC quality in Norwegian dairy cattle. When grouped by breed, lactation, and storage method, distribution of IgG was similar; however, pooled samples had a slightly greater percentage of samples containing < 50 mg/ml IgG. This is potentially due to dilution of IgG by larger volumes of low quality colostrum.

Regionally, the samples collected in the Midwest had the greatest IgG concentration and the greatest percentage of samples containing > 50 mg/ml IgG. A second quality measurement of MC is bacterial contamination. It has been demonstrated that higher bacterial loads reduced uptake of IgG in newborn calves. Calves receiving the MC with lower bacterial contamination had greater 24 h serum IgG concentrations compared to their counterparts. Over 50% of the MC samples collected in our study had TPC less than 100,000 cfu/ml, however over 27% of the samples collected had TPC greater than 500,000 cfu/ml. This may introduces a huge immunological challenge to newborn calves who are not equipped to handle a large pathogen load. Regionally, the Southeast had the greatest mean TPC and greatest percentage of samples containing > 100,000 cfu/ml. This is likely due to the hot and humid climate that supports bacterial growth. Over 60% of the samples that were fresh or frozen prior to sample collection had TPC below 100,000 cfu/ml, while over 40% of refrigerated samples had TPC higher than 1 million cfu/ml. Storage method impacts MC quality by altering bacterial growth and shelf life. Previous research has observed that refrigeration slows pathogen growth compared to unrefrigerated samples if MC is stored for 24 h. Current recommendations are for MC to be refrigerated if fed within 24 h of collection and frozen if it is going to be stored for more than 24. The 2007 NAHMS report observed that 60.7% of MC being hand-fed was fed fresh or stored without refrigeration, 11.1% was refrigerated and 28.2% was frozen prior to feeding. Data from our study suggests there would be benefits associated with an industry shift towards an increase in freezing MC as compared to feeding refrigerated or fresh MC.

In the United States 19.2% of calves have FPT and 7.8% of heifer calves that are born alive die prior to weaning. Providing adequate MC is one practice that can reduce these values. A total of 70.6% of samples collected met the industry recommendation for IgG concentration with 15.1% of samples containing > 100 mg/ml. Only 54.8% of samples collected met the industry recommendation for TPC, with 26.8% of samples having a TPC > 500,000 cfu/ml. Combining industry recommendations for TPC and IgG resulted in only 39.4% of MC samples as adequate. The Midwest had the greatest percentage of samples that met both industry recommendations, while the Southeast had the lowest percentage of samples that met both recommendations.

A greater percentage of fresh and frozen samples met the TPC recommendation as compared to refrigerated samples (Table 7). Similar percentages of fresh and frozen samples were adequate, while 53.1% of refrigerated samples met the IgG recommendation but not the TPC recommendation. Lactation and breed did not impact the percentage of samples that met one or both industry recommendations.

**Table 7. Percentage of samples meeting one or both industry recommendations for colostrum quality by storage method prior to sample collection.**

| | Fresh | | Refrigerated | | Frozen | |
|---|---|---|---|---|---|---|
| Quality | n | (%) | n | (%) | n | % |
| > 50 IgG < 100,000 TPC | 76 | 42.0 | 30 | 18.5 | 188 | 46.7 |
| > 50 IgG >100,000 TPC | 38 | 21.0 | 86 | 53.1 | 109 | 27.0 |
| < 50 IgG >100,000 TPC | 21 | 11.6 | 38 | 23.5 | 45 | 11.2 |
| < 50 IgG <100,000 TPC | 46 | 25.4 | 8 | 4.9 | 61 | 15.1 |
| Total | 181 | 100 | 162 | 100 | 403 | 100 |

## Conclusions

Objectives of this study were to characterize the IgG concentration, bacterial contamination and nutrient composition of MC available on U.S. dairy operations. Storage method of MC has a significant impact on bacterial contamination. Based on this data, MC should be fed fresh or frozen immediately and not stored in a refrigerator. This study observed IgG concentration in MC ranging from < 1.8 to 200.2 mg/ml; of the 827 samples collected 29.4% did not meet the industry standard. Bacterial contamination of MC continues to be a problem on many farms, with only 54.8% of the samples with TPC < 100,000 cfu/ml (industry recommendation), with the greatest problems occurring in the Southeast region of the United States. When both industry standards for MC quality were combined only 39.41% percent of samples were adequate; this value was 53.7% in the Midwest and only 14.9% in the Southeast. Data collected from this study indicates that a large percentage of calves are being put at risk for both FPT and pathogen exposure when fed MC currently available on US farms.